

[Name of Document]        SPECIFICATION

[Title of the Invention]

IMAGE PROCESSING APPARATUS AND METHOD, AND DISTRIBUTION  
MEDIUM

[Claims]

[Claim 1] An image processing apparatus for generating a motion signal for controlling motion in accordance with an image, said image processing apparatus comprising:

detection means for detecting a motion vector from said image signal; and

generation means for generating said motion signal from a motion vector detected by said detection means.

[Claim 2] An image processing apparatus according to claim 1, wherein said detection means detects said motion vector for each block composed of a plurality of pixels positioned at predetermined positions within a frame.

[Claim 3] An image processing apparatus according to claim 1, wherein said generation means generates a horizontal component, a vertical component, a magnification component, and a rotation component from the motion vector detected by said detection means, and generates said motion signal from these four components.

[Claim 4] An image processing method for use with an image processing apparatus for generating a motion signal for controlling motion in accordance with an image, said

image processing method comprising:

a detecting step for detecting a motion vector from said image signal; and

a generating step for generating said motion signal from a motion vector detected in said detecting step.

[Claim 5] A distribution medium for providing a computer-readable program to an image processing apparatus for supplying a motion signal for controlling motion in accordance with an image in order to execute:

a detecting step for detecting a motion vector from said image signal; and

a generating step for generating said motion signal from a motion vector detected in said detecting step.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

The present invention relates to an image processing apparatus and method, and a distribution medium. More particularly, the present invention relates to an image processing apparatus and method for detecting a motion vector from an input image signal and for generating a motion signal for controlling the motion of a chair for an observer who views an image from the detected motion vector, and to a distribution medium therefor.

[0002]

[Description of the Related Art]

An apparatus in which, when an observer is viewing an image, verisimilitude is improved by moving, in accordance with the image, the motion of a chair on which the observer is sitting, is known. A motion signal, which is supplied to such an apparatus to cause a chair to move, is generated from data obtained by a sensor for detecting an angle at the same time when an image is captured, or a motion signal is generated through a manual operation by observing the captured image by a person and by predicting motion by that person.

[0003]

[Problems to be Solved by the Invention]

In the above-described apparatus, when a motion signal for a chair is generated by a sensor, data for generating the motion signal must be recorded at the same time the image is captured. Therefore, it is not possible to generate a motion signal by using an image which has already been captured.

[0004]

Also, when a person observes a captured image and a motion signal is generated, a manual operation is required, presenting a problem in that processing takes a long time.

[0005]

The present invention has been achieved in view of such

circumstances. The present invention aims to easily generate a motion signal also from an image which has already been captured by detecting a motion vector from an input image and by generating a motion signal from the detected motion vector.

[0006]

[Means for Solving the Problems]

The image processing apparatus as set forth in claim 1 comprises detection means for detecting a motion vector from an image signal; and generation means for generating a motion signal from the motion vector detected by the detection means.

[0007]

The image processing method as set forth in claim 4 comprises a detecting step for detecting a motion vector from an image signal; and a generating step for generating a motion signal from the motion vector detected by the detection means.

[0008]

The distribution medium as set forth in claim 5 provides a computer-readable program to an image processing apparatus in order to execute a process comprising: a detecting step for detecting a motion vector from an image signal; and a generating step for generating a motion signal from the motion vector detected in the detecting step.

[0009]

In the image processing apparatus as set forth in claim 1, the image processing method as set forth in claim 4, and the distribution medium as set forth in claim 6, a motion vector is detected from an image signal, and a motion signal is generated from the detected motion vector.

[0010]

[Description of the Embodiment]

Fig. 1 is a block diagram showing the construction of an embodiment of an image processing apparatus of the present invention. An image signal supplied from an image tape recorder (not shown), etc., is supplied to a display section 1 formed of a display and an image processing apparatus 2. The image processing apparatus 2 generates a control signal (motion signal) for driving a driving section 3.

[0011]

The image processing apparatus 2 comprises a feature quantity detection section 11 and a feature quantity processing section 12. A signal input to the image processing apparatus 2 is input to the feature quantity detection section 11 whereby feature quantity (to be described later) is detected and is output to the feature quantity processing section 12. The feature quantity processing section 12 computes a motion signal to be

supplied to the driving section 3 from the input feature quantity. The driving section 3 drives (moves) a chair on which an observer who observes an image sits in accordance with the input motion signal. This point will be described later.

[0012]

Fig. 2 is a block diagram showing the construction of the feature quantity detection section 11. The image signal input to the feature quantity detection section 11 is delayed by an amount corresponding to one frame by a delay section 21, after which it is supplied to a frame buffer 22-1 and is also supplied to a frame buffer 22-2. Reading sections 23-1 and 23-2 read an image signal from the corresponding frame buffers 22-1 and 22-2 in accordance with a predetermined pattern stored in a memory 24, and output the image signal to a motion vector detection section 25.

[0013]

The motion vector detection section 25 detects a motion vector from the supplied image signal and outputs the motion vector to a feature quantity computation section 26. The feature quantity computation section 26 computes feature quantity from the input motion vector.

[0014]

Next, the operation of the feature quantity detection section 11 shown in Fig. 2 is described. At time  $t$ , the

image signal input to the feature quantity detection section 11 is supplied to the delay section 21 and the frame buffer 22-2. The frame buffer 22-2 stores input image signals for one frame. Since the delay section 21 delays the image signal by an amount corresponding to one frame, at time  $t$ , an image signal at time  $t-1$  earlier than time  $t$  (an image signal one frame before that at time  $t$ ) is stored in the frame buffer 22-1. The image signal at time  $t-1$ , stored in the frame 22-1, is read by the reading section 23-1, and the image signal at time  $t$ , stored in the frame buffer 22-2, is read by the reading section 23-2.

[0015]

The reading sections 23-1 and 23-2 read an image signal in a portion corresponding to the pattern stored in the memory 24 from among the image signals stored in the corresponding frame buffers 22-1 and 22-2. Here, a pattern stored in the memory 24 is described with reference to Fig. 3.

[0016]

Fig. 3 shows an example of a pattern stored in the memory 24. In the case of those portions of the pixels forming one frame, which are not related to motion, for example, image signals captured by a video camera mounted to an automobile, such as that shown in Fig. 4, the hood portion of the automobile is determined to be an area which

is not related to motion, and the pixel positioned at the center of the area from which that area has been removed is denoted as a convergence point P. For example, 25 representative points Q (including the convergence point) which are symmetrical horizontally and vertically about the convergence point P are set. For each representative point Q, a block B, composed of a predetermined number of pixels, with the representative point Q being positioned at the center, for example, a block B composed of  $33 \times 33$  pixels, is set. In the memory 24, the coordinates of each representative point Q within the image plane of such a frame, and the size of the block B are stored as a pattern.

[0017]

The reading section 23-1 reads pixel data corresponding to the pattern such as that described above stored in the memory 24, that is, pixel data within each block B, in accordance with the coordinates of the representative point Q and the size of the block B from among the image signals at time  $t-1$  stored in the frame buffer 22-1, and outputs the pixel data, as the data of the reference block, to the motion vector detection section 25. In a similar manner, the reading section 23-2 reads pixel data corresponding to the pattern stored in the memory 24 from among the image signals at time  $t$  stored in the frame buffer 22-2, and outputs the pixel data, as the data of the retrieval block,

to the motion vector detection section 25.

[0018]

The motion vector detection section 25 detects the motion vector at each representative point Q by performing block matching by using the input data of the reference block and the input data of the retrieval block. Therefore, in the case of this example, 25 motion vectors are detected.

[0019]

The feature quantity computation section 26 computes, based on the equations shown below, a total of four components of a horizontal component u, a vertical component v, a magnification component  $v_{\text{zoom}}$ , and a rotation component  $v_{\text{rot}}$  of the motion of the frame (image plane) by using the 25 motion vectors detected by the motion vector detection section 25.

$$\text{Horizontal component } u = (1/n) \sum u_i \dots (1)$$

$$\text{Vertical component } v = (1/n) \sum v_i \dots (2)$$

$$\text{Magnification component } v_{\text{zoom}} = (1/n) \sum v_{\text{zoom}i}/d_i \dots (3)$$

$$\text{Rotation component } v_{\text{rot}} = (1/n) \sum v_{\text{rot}i}/d_i \dots (4)$$

where the subscript i indicates the number affixed to the representative point  $Q_i$ , which varies from 1 to 25 in this example, and n indicates the number of representative points, which is 25 in this example. The values obtained by equations (1) to (4) are the average value of each component u, v,  $v_{\text{zoom}}$ , and  $v_{\text{rot}}$  obtained by the motion vector detection

section 25.

[0020]

The relationship among the above-mentioned components  $u$ ,  $v$ ,  $v_{\text{zoom}}$ , and  $v_{\text{rot}}$  is described with reference to Fig. 5. The horizontal component of a motion vector  $T$  of a representative point  $Q_i$  for the object of processing is denoted as  $u_i$ , and the vertical component is denoted as  $v_i$ .  $d_i$  is a scalar quantity indicating the distance from the convergence point  $P$  to the representative point  $Q_i$ .  $(P_x, P_y)$  indicates the coordinates of the convergence point  $P$ , and the distance up to the representative point  $Q_i$  of the coordinates  $(Q_{ix}, Q_{iy})$  is computed with these coordinate values as a reference.

[0021]

The component  $(u_i, v_i)$  of this motion vector  $T$  is a component when the representative point  $Q_i$  is assumed to be the origin. The component in a direction parallel to the straight line which connects the convergence point  $P$  to the representative point  $Q_i$ , of the motion vector  $T$  is denoted as  $v_{\text{zoom}i}$ , and the component in a direction perpendicular to the straight line which connects the convergence point  $P$  to the representative point  $Q_i$  is denoted as  $v_{\text{rot}i}$ . Also, the angle formed between the straight line which connects the convergence point  $P$  to the representative points  $Q_i$  and the motion vector  $T$  is denoted as  $\theta$ . At this time,  $v_{\text{zoom}i}$  and

$v_{roti}$  are determined based on the following equations.

$$v_{zoomi} = (u_i^2 + v_i^2)^{(1/2)} \cos\theta \quad \dots (5)$$

$$v_{roti} = (u_i^2 + v_i^2)^{(1/2)} \sin\theta \quad \dots (6)$$

[0022]

The feature quantity computation section 26 computes four component data  $u$ ,  $v$ ,  $v_{zoom}$ , and  $v_{rot}$ , as feature quantity, by using equations (1) to (4) from the motion vector output from the motion vector detection section 25. The computed four component data  $u$ ,  $v$ ,  $v_{zoom}$ , and  $v_{rot}$  are output to the feature quantity processing section 12 (Fig. 1).

[0023]

Here, for example, when an observer is made to virtually experience the feeling of riding in an automobile, the types of forces (motions) which should be applied to the chair on which the observer is sitting are considered. Examples of forces applied to the chair of the automobile include a force for representing the forward-rearward inclination of the surface of the road when the automobile is running on a sloping road, such as, a grade, a force for representing vibrations which are received from the surface of the road when the automobile is running on a bumpy road, and a force for representing the inclination in the left-right direction of the surface of the road when the automobile is running on a sloping road.

[0024]

These forces are stimuli (actual stimuli) which are actually applied to an automobile to which a video camera which has captured an image is mounted. Forces similar to these actual stimuli may be applied to the chair for the observer who observes the image. For example, if the actual stimulus is a right-inclined force, a right-inclining force may be applied to the chair for the observer as well. These forces are forces which are applied without being influenced by the physical condition of the chair for the observer, for example, the condition in which the chair can be moved back and forth only within a predetermined range.

[0025]

In contrast, a force for representing the centrifugal force when the automobile is turning on a curve, a force for representing the inertial force during acceleration and deceleration, and a force for representing the yawing of the automobile in a curve must be applied as simulated forces (simulated stimuli) because the center of gravity of the chair on which the observer is sitting cannot be moved due to physical conditions. For example, since the chair cannot be moved forward in an accelerated manner so as to represent the inertial force during acceleration, a simulated stimulus must be applied to the chair for the observer.

[0026]

The relationship among the force concerning the above-

mentioned actual stimulus and the simulated stimulus, the component of the motion signal which is actually applied to the chair for the observer, and the four components computed by the feature quantity computation section 26 is shown below.

#### Actual stimulus

Component to be represented	Motion signal component	Relationship with 4 components
Forward-rearward inclination of surface of road	pitch	Low-frequency component of $\Sigma v$
Vibrations received from surface of road	z	High-frequency component of $-\Sigma v$
Left-right inclination of surface of road	roll	$-\Sigma v_{\text{rot}}$

#### Simulated stimulus

Component to be represented	Motion signal component	Relationship with 4 components
Centrifugal force in curve	roll	u
Centrifugal force	pitch	Low-frequency components

due to acceleration  
and deceleration

of  $dv_{\text{zoom}}/dt$

Automobile  
yawing in  
curve

yaw

-u

[0027]

The feature quantity processing section 12 generates a motion signal to be supplied to the driving section 3 (Fig. 1) by using the above-described relationships. Fig. 6 is a block diagram showing the construction of the feature quantity processing section 12. Among the four components output from the feature quantity detection section 11, the rotation component  $v_{\text{rot}}$  is input to an adder 31-1, the horizontal component  $u$  is input to an adder 31-2 and a code inverter 32-1, the vertical component  $v$  is input to an adder 31-3, and the magnification component  $v_{\text{zoom}}$  is input to an adder 31-5 and a delay unit 33-3. The data output from the adder 31-1 is delayed by an amount corresponding to one clock by the delay unit 33-1, after which it is fed back and is input to the adder 31-1. In a similar manner, the data which is output from the adder 31-3 is delayed by an amount corresponding to one clock by a delay unit 33-2, after which it is fed back and is input to the adder 31-3 as well.

[0028]

The data output from the delay unit 33-1 is input to

the adder 31-2, and the data output from the delay unit 33-2 is output to an HPF (High-Pass Filter) 34 via a code inverter 32-2 and is also output to an adder 31-4 via an LPF (Low-Pass Filter) 35-1. The magnification component  $v_{\text{zoom}}$  which is delayed by an amount corresponding to one clock by the delay unit 33-3 is subtracted from the magnification component  $v_{\text{zoom}}$  input to an adder 31-5, and the resulting component is input to an adder 31-4 via an LPF 35-2.

[0029]

Next, a description is given of the computation of the motion signal components "roll", "yaw", "z", and "pitch", performed by the feature quantity processing section 12. The rotation component  $v_{\text{rot}}$  input to the feature quantity processing section 12 is input to the adder 31-1. The adder 31-1 adds together the rotation component  $v_{\text{rot}}$  which is input at time  $t$  and the data which is output one unit time before at time  $t-1$  from the delay unit 33-1. The adder 31-1 computes the motion signal component "roll" ( $\Sigma v_{\text{rot}}$ ) which represents the left-right inclination of the surface of the road by accumulating (integrating) the rotation component  $v_{\text{rot}}$  in this manner. However, since the motion signal component "roll" representing the left-right inclination of the surface of the road is  $-\Sigma v_{\text{rot}}$ , the adder 31-2 uses, for computation, data such that the code of the data input from the delay unit 33-1 is inverted.

[0030]

The motion signal component "roll" (horizontal component  $u$ ) is also used to represent the centrifugal force in a curve. Accordingly, the adder 31-2 computes the motion signal component "roll" to be supplied to the driving section 3 by adding together (subtracting the output of the delay unit 33-1 from the horizontal component  $u$ ) the data such that the code of the data input from the delay unit 33-1 is inverted and the horizontal component  $u$ .

[0031]

Since the motion signal component "yaw" of the yawing of the automobile in a curve is obtained by inverting the value of the horizontal component  $u$ , the feature quantity processing section 12 computes the motion signal component "yaw" by causing the code inverter 32-1 to invert the code of the value of the input horizontal component  $u$ .

[0032]

The adder 31-3 adds together the vertical component  $v$  which is input at time  $t$  and the vertical component  $v$  which is output one unit time before at time  $t-1$  from the delay unit 33-2. In this manner, the vertical component  $v$  is accumulated (integrated) by the adder 31-3. Then, the data which is accumulated by the adder 31-3 and the delay unit 33-2 is input to the code inverter 32-2 whereby the code is inverted, and further, only the high-frequency components

are extracted by the HPF 34. In this manner, the motion signal component  $z$  representing the vibrations received from the surface of the road is computed.

[0033]

Furthermore, the data output from the delay unit 33-2 is also output to the LPF 35-1 whereby the low-frequency components are extracted. In this manner, the motion signal component "pitch" representing the forward-rearward inclination of the surface of the road is computed. The motion signal component "pitch" is also used as a motion signal component representing the inertial force by acceleration and deceleration. For this reason, the motion signal component "pitch" output from the LPF 35-1 is added to the motion signal component "pitch" representing the inertial force by the adder 31-4.

[0034]

The motion signal component "pitch" representing the inertial force is computed from the magnification component  $v_{\text{zoom}}$  input to the feature quantity processing section 12. The magnification component  $v_{\text{zoom}}$  input to the feature quantity processing section 12 is input to the adder 31-5 and the delay unit 33-3. A magnification component  $v_{\text{zoom}}t$  which is input at time  $t$  and a magnification component  $v_{\text{zoom}}t-1$  at time  $t-1$ , delayed by one unit time by the delay unit 33-3, are input to the adder 31-5. The adder 31-5

differentiates the magnification component  $v_{\text{zoom}}$  by subtracting the magnification component  $v_{\text{zoom}}t-1$  at time  $t-1$  from the magnification component  $v_{\text{zoom}}t$  input at time  $t$ . Then, the LPF 35-2 extracts the low-frequency components from the value output from the adder 31-5, thereby computing the motion signal component "pitch" representing the inertial force by acceleration and deceleration.

[0035]

The adder 31-4 adds together the value output from the LPF 35-1 and the value output from the LPF 35-2, thereby computing the motion signal component "pitch" to be supplied to the driving section 3.

[0036]

An example of the driving section 3 is shown in Figs. 7 and 8. Fig. 7 is a side view of the driving section 3. Fig. 8 is a view when the driving section 3 is seen from above. The driving section 3 comprises six pistons 41-1 to 41-6, with a base 42 being supported by these pistons. The base 42 has a chair 43 fixed thereto so that an observer 44 may sit on this chair 43.

[0037]

The pistons 41-1 to 41-6 are capable of extending and retracting along their central axes. As a result of the extending and retracting motion by the pistons 41-1 to 41-6, the base 42 jerks, and furthermore, the chair 43 fixed to

the base 42 jerks. A signal for controlling the pistons 41-1 to 41-6 is generated and supplied by the feature quantity processing section 12 in a manner as described above.

[0038]

As described above, in the present invention, the motion signal component is computed from the motion vector obtained from the image. This makes it possible to obviate the need to generate the motion signal component in advance in order to input it. In addition, it is possible to easily generate a motion signal component from the image in which a motion signal component is not generated.

[0039]

In this specification, examples of distribution media for providing a computer program for executing the above-described processing to a user include an information recording medium, such as a magnetic disk or a CD-ROM, and transmission media by a network, such as the Internet or a digital satellite.

[0040]

[Advantages]

According to the image processing apparatus as set forth in claim 1, the image processing method as set forth in claim 4, and the distribution medium as set forth in claim 6, a motion vector is detected from an image signal, and a motion signal is generated from the detected motion

vector. This makes it possible to easily generate a motion signal to be supplied to the apparatus for causing a chair for an observer to jerk in accordance with the image.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a block diagram showing the construction of an embodiment of an image processing apparatus of the present invention.

[Fig. 2]

Fig. 2 is a block diagram showing the construction of a feature quantity detection section 11 of Fig. 1.

[Fig. 3]

Fig. 3 shows a pattern stored in a memory 24 of Fig. 2.

[Fig. 4]

Fig. 4 shows an image to be processed.

[Fig. 5]

Fig. 5 is an illustration of a vector to be computed.

[Fig. 6]

Fig. 6 is a block diagram showing the construction of a feature quantity processing section 12 of Fig. 1.

[Fig. 7]

Fig. 7 is a side view of a driving section 3.

[Fig. 8]

Fig. 8 is a view when the driving section 3 is seen from above.

[Reference Numerals]

2 image processing apparatus, 11 feature quantity  
detection section, 12 feature quantity processing section,  
21 delay section, 22 frame buffer, 23 reading section,  
24 memory, 25 motion vector detection section, 26  
feature quantity computation section, 31 adder, 32 code  
inverter, 33 delay unit, 34 HPF, 35 LPF